
**चक्रवात आश्रयों की रचना और निर्माण —
दिशानिर्देश**

**Design and Construction of Cyclone
Shelters — Guidelines**

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Cyclone Resistant Structures Sectional Committee had been approved by the Civil Engineering Division Council.

India is highly vulnerable to a variety of natural and manmade disasters. Among natural hazards, the most notable ones are earthquakes, cyclones, floods and droughts. Tsunami is an additional concern after the Indian Ocean tsunami of 26 December 2004. These natural hazards pose an enormous threat to the developmental process of the country and lead to avoidable losses of life and property. India's vulnerability to tropical cyclones is well known.

Cyclones are destructive because of their associated large spread, long duration high speed rotatory winds, accompanied by very heavy rainfall and storm surge. It is more so when these strike coasts of countries/states bordering the North Bay of Bengal because of the associated high storm surge in this region. Shallow bay, low flat zigzag terrain, high astronomical tides, high density of population, socio-economic conditions, lack of awareness, inadequate preparedness and absence of hedging mechanisms add to the problem.

Most parts of coastal India are susceptible to high wind speed exceeding 50 m/s (180 km/h) and short duration gusts of higher speeds, and probable maximum storm surge height varying considerably. Surge varies from place to place and variation is not linear. At some places, variation of surges between two points close to each other is large due to bathymetry and terrain conditions.

The only prescribed measures to save vulnerable populations from the onslaught of a cyclone are to temporarily evacuate the population on receipt of advance warnings and look after them for 2 to 3 days by arranging shelter, food and health-care facilities. Therefore, construction of shelters along vulnerable coastal areas is one of the important cyclone risk mitigation measures.

Worldwide, construction of cyclone shelters has been a proven means of disaster preparedness as the vulnerable population can be evacuated to these structures immediately after receiving the cyclone warning. Realizing the need, initiatives were taken by engineering establishments including research and development outfits to design and construct cyclone shelters. There is now a history of almost 50 years in construction and maintenance of cyclone shelters, notably in states such as Andhra Pradesh, Orissa and Tamilnadu. Cyclone shelters constructed in these states have proved effective and become a source of motivation for improved preparedness. The existing number of cyclone shelters in India is, however, not sufficient to accommodate the vulnerable population in coastal areas. Hence, action is needed to bridge the existing gaps. These shelters may also be used during/post-tsunami hazard. Cyclone shelters can be utilized, at normal times, as community buildings, which will permit the use of the building as emergency shelter without any difficulty. Consideration of the local ethos and values in the design of shelters would improve their acceptability and use. These facts have to be taken into consideration while designing the cyclone shelters.

This standard has been formulated to provide guidelines to concerned authorities and stakeholders in design and construction of cyclone shelters. In the formulation of this standard, due weightage has been given to international coordination among the standards and practices prevailing in different countries in addition to relating them to the practices in the field in this country.

The composition of the Committee responsible for the formulation of this standard is given in Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESIGN AND CONSTRUCTION OF CYCLONE SHELTERS — GUIDELINES

1 SCOPE

This standard lays down guidelines for the selection of location, capacity, design, structural safety, water supply, sanitation, lighting, ventilation, power back-up, and, maintenance and some other aspects necessary for the design and construction of cyclone shelters.

2 REFERENCES

The Indian Standards given below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards given below:

<i>IS No.</i>	<i>Title</i>
456 : 2000	Plain and reinforced concrete — Code of practice (<i>fourth revision</i>)
800 : 2007	General construction in steel — Code of practice (<i>third revision</i>)
801 : 1975	Code of practice for use of cold-formed light gauge steel structural members in general building construction (<i>first revision</i>)
875 (Part 3) : 2015	Code of practice for design loads (other than earthquake) for building and structures: Part 3 Wind loads (<i>third revision</i>)
1786 : 2008	High strength deformed steel bars and wires for concrete reinforcement — Specification (<i>fourth revision</i>)
1905 : 1987	Code of practice for structural use of un-reinforced masonry (<i>third revision</i>)
15498 : 2004	Guidelines for improving the cyclonic resistance of low rise houses and other buildings/structures

3 GENERAL GUIDELINES FOR DESIGN OF CYCLONE SHELTERS

While designing cyclone shelters, the issues given in 3.1 to 3.3 should be given due consideration.

3.1 Normal Use and Emergency Uses

Cyclone shelters are often used for a short period of time during the occurrence of cyclones. Sustainability of these shelters depends on their use and maintenance during normal times when there is no occurrence of cyclone.

NOTE — Substantial investments are made to erect cyclone shelters. It is thus prudent that these structures are put to various other uses that will take care of maintenance of the shelter as well.

3.2 Number of Cyclone Shelters and Accommodation Capacity

The number of cyclone shelters to be built largely depends on the number of vulnerable people to be sheltered during emergencies. The effectiveness of a cyclone shelter, thus, depends on the assessment for the number of likely users and considerations thereof in the functional and structural design aspects of the shelter.

Some of the parameters to be considered are the population density and the likelihood of its increase based on town/city planning. Similarly, in hilly terrains the possibility of occurrence of landslides cutting off regions into pockets should be considered.

Experience on capacity assessment of cyclone shelter indicates that, on an average, about 50 to 60 percent of total population of vulnerable locations may be using the cyclone shelter during emergencies. Area required shall be computed on the basis of catchment area and number of people expected at the time of disaster. The shelter design density may be taken as a minimum floor area of 1 m² per person.

Separate cooking area with proper hygiene, storage, water supply, and drainage and fire safety is necessary under such emergency conditions and accordingly provisions should be made during floor area planning.

3.3 Multi-Hazard Resistance of Cyclone Shelters

It is necessary that the cyclone shelters are multi-hazard resistant for the reason that part of the coastal areas are multi-hazard prone.

4 DESIGN CONSIDERATIONS

4.1 Based on the experiences of various states in construction and maintenance of cyclone shelters a common strategy has been evolved for sustainable use of the shelters. It is to be noted that the states need to have maximum leverage in deciding the appropriateness

of each element described in this standard. The larger experience suggests that the construction and maintenance of cyclone shelters would be sustainable only when the local communities are involved at all stages which enables the communities to identify the aesthetically appealing and functionally efficient cyclone shelters as their own and put to use throughout the year. Hence, it is suggested that the states may associate the local bodies such as Panchayat Raj Institutions and Urban Local Bodies in the selection process for the location and use of the shelters.

4.2 The long coast line of India, is also vulnerable to various other kinds of natural hazards, whose intensity varies. Whereas the design of the shelters in the cyclone affected parts will consider the relevant wind speeds and the associated surge and flooding due to rain, the design should be safe also for other hazards, primarily seismicity.

4.3 Understandably the primary loading for shelters, except where seismicity is also to be considered, will be on account of wind. However being uncommon structures of non-standard shapes, shelters are unlikely to be covered in wind loading codes for their wind pressures. It is advisable, therefore, that for these life-line structures required to cater to emergent situations of cyclone occurrence, wind pressures are determined through wind tunnel study. Even more important, from this point of view, is the case of shelters constructed on stilts preferred for escape of flood waters (on account of surge or heavy rains accompanying a cyclonic storm). For such cases, the bottom floor slab is subject to large suctions, which are additive to dead and imposed loads. While developing designs likely impact of wind/water borne debris should also be accounted for and it shall be ensured that the buildings are capable of withstanding such impacts.

4.4 The recommendations for construction of cyclone shelters deal with the following design and construction aspects of cyclone shelters:

- a) Accommodation capacity,
- b) Location,
- c) Building,
- d) Height of the cyclone shelter,
- e) Material selection,
- f) Structural specifications,
- g) Inner design,
- h) Staircases,
- j) Water supply,
- k) Toilets and sewerage,
- m) Provision for helipads,
- n) Construction of earthen mounds (*Killas*),
- p) Sustainable Use (*see* ANNEX A),
- q) Special foundation design, and
- r) Other considerations.

5 LOCATION AND EASE OF ACCESSIBILITY TO VEHICLES/PEDESTRIANS DURING AND AFTER EMERGENCIES

The effectiveness of a cyclone shelter depends on its location. Considering the logistics of rescue, evacuation and transfer to a shelter, as well as the likely catchment area, the shelter may be located, as far as possible from the coast, but not less than 1.5 km unless topography permits so. A larger distance will help in much reduced levels of water (due to surge or flooding) that will be encountered, and will ease the accessibility to the shelter. The following points may also be considered:

- a) Cyclone shelters should be located on available elevated land. Guidance on the levels can be taken from large scale maps or from Survey of India. Exact location within the broad contour is left to the decision making mechanism adopted locally involving communities and local authorities.
 - b) In the absence of available elevated area, the structure may be elevated through construction of a mound or shelter be built on stilts. However, it is pointed out that foundations will be flooded during cyclones and the design of the soft story (in case of stilts) shall have to provide for adequate safety under that condition against wind as well as, where applicable against seismic loading.
 - c) States are advised to carry out a survey within 10 km band width from the coast and identify all villages therein and submit the list to the Survey of India which should provide the information on astronomical high-tide levels and ground levels within a level range of + 0.5 m.
- NOTE — High tide line on the coast may be verified from the Coastal Regulation Zone (CRZ) Notification by authorized agencies.
- d) Regenerating mangroves and raising shelter belt plantations will help in reducing the fury of the storm surge. Suitable isolation distance must be provided between the shelter belt and the cyclone shelter to avoid damage to the foundation of the building by the roots of the trees in the belt. In case of open foundation, necessary protection be given to the mounds by providing pitching and by constructing toe wall.
 - e) The cyclone shelter should be easily accessible to vehicles and pedestrians and the road should not have steep slope and not be crossing a flood prone water body. The approach road and the shelter location should be so selected that they have very low risk of falling trees or falling structures or overhead lines. In case of one route getting choked/jammed/blocked, alternate route

is essential. If shelter is not in the elevated land, ensure the access is free of flooding for emergency vehicles.

- f) Geotechnical investigation should be carried out to ensure that during flooding there is no risk of sliding through slip-circle failure at the chosen location.
- g) The shelter shall not be located near hazardous materials like fuel or chemical storage, physical hazards like other building or heavy falling debris, high voltage overhead power lines etc.

6 BUILDING

The following considerations may be kept in view with respect to the cyclone shelter building:

- a) The maximum number of stories shall not exceed two. These may be constructed using RCC, braced steel frame or masonry, with or without stilt, depending on the storm tide levels (high tide + storm surge). Height depends on the storm tide levels. In view of general soft top soil in coastal areas, pile foundation is preferable. However, suitable type of foundations should be considered based on recommendation of geotechnical investigation, local conditions and soil strata.
- b) *Plan shape* — Any shape (preferably circular, hexagonal or octagonal) is suitable. However, square or rectangular shape may be used provided the peripheral corners are rounded for improving the aerodynamics of the structure.
- c) *Doors* — To be made of fibre reinforced plastics (FRP)/anodized aluminium, should be openable outwards and use sturdy stainless steel fittings to be able to sustain high wind pressures, and impact by debris.
- d) *Windows* — Louver type of window is suggested with non-breakable and non-brittle material. Fibre reinforced plastics (FRP)/anodised aluminium should be considered. These should be able to sustain high wind pressures, and impact by debris.
- e) Doors and Windows should be provided with suitable bolting/locking mechanism to ensure that they are not blown out due to internal wind pressure.
- f) *Parapet* — The height of the parapet should be minimum 1.2 m.

7 HEIGHT OF THE CYCLONE SHELTER

The total height of the structure may be worked out as per the following guidelines:

- a) Finished ground level should be at least 1 m above the storm tide levels.
- b) Raise the plinth about 1.2 to 1.5 m above the finished ground level.
- c) Storey height should be kept as 3.5 m minimum.

8 MATERIAL SELECTION

The following considerations may be kept in view while selecting materials:

- a) Load bearing brick masonry structure as per IS 1905 may be adopted where there is no requirement of stilt. All stilted shelters should be raised on RCC or steel frame and upper portion (first floor and above) could be constructed with load bearing confined brick masonry structure as an alternative to continuing the framed structure.
- b) For RCC frame structure, minimum grade of concrete shall be M 30. Good concrete with proper cover to steel results in a durable structure. In this regard, provisions of IS 456 shall be applied. An additional cover of 5 mm, as compared to the normal provisions of IS 456 shall be provided. Selection of cement type shall be in accordance with IS 456, suitable to environment and aggressive conditions encountered. Reinforcing steel conforming to IS 1786 shall be used.
- c) Wherever steel structure is constructed, it shall conform to IS 800 or IS 801. Suitable corrosion resistance measures should be taken, particularly since shelters will be on the sea coast and subjected to marine environment.
- d) With steel frame construction, insulating puf panel can be used on roof and external walls. For internal wall, light weight dry wall option may be considered. Use of metal sheet alone should be avoided on external surfaces, since that could produce unacceptable noise levels during a storm.

All the materials shall conform to the relevant Indian Standards.

9 STRUCTURAL CONSIDERATIONS

The following structural considerations shall be made:

- a) Imposed load for floor slab and roof terrace shall be taken as 5 kN/m² and 3 kN/m², respectively.
- b) Wind load shall as per IS 875 (Part 3) and IS 15498.
- c) Earthquake load shall not be considered simultaneously with that of wind load. Earthquake Importance Factor shall be taken as 1.5 for the shelter design. Other norms should be followed from the relevant Indian Standards.
- d) Vents shall be provided as per the norms for adequate ventilation. Louvered vents to be used in shelter in various walls just above floor level to drain water flowing in and out in case of higher than first floor surge height.
- e) All internal walls, etc, shall be designed to withstand internal wind pressures.

10 INNER DESIGN

The following functional aspects shall be taken care of while designing the space/utilities:

- a) Bunk beds with resting facility one for every 25 persons may be provided for small children, elderly/sick persons.
- b) Storage shelf facilities of 0.05 m³ per person may be provided for accommodating the personal belongings of the occupants.
NOTE — it is intended that people enter the shelter with minimal personal effects, such as personal papers and valuables, special medicines, baby needs, battery radio, torch, light snacks and drinks.
- c) Provide adequate storage facilities to accommodate first aid kits, drinking water containers, search and rescue equipment, common kitchen utensils, etc.
- d) Adequate provision shall be made for proper lighting and ventilation even during a storm to prevent people from panicking.

11 STAIRCASES

The following considerations shall be made for design of staircase:

- a) Staircases need to be located up to terrace level and shall be spacious enough for the movement of the people. The staircases shall have a width of 2.0 m to 2.5 m depending on shelter capacity with multi-entry possibilities. The maximum height of riser shall be 150 mm and the number of steps should be limited to 15 per flight.
- b) A ramp with a slope of 1 in 12 shall be considered up to the first floor for carrying persons with disabilities and the elderly. The ramp shall have a width of 2.0 m to 2.5 m.
- c) Staircases shall be health, safety and environment (HSE) compliant.
- d) Provide handrails on both sides of the staircase and ramp even if these are next to a wall.
- e) The provision of the fire exit shall be made. If ramp and staircase are provided at two extreme ends of the building then these may be treated as fire exit. For fire exit slider may also be used.

12 ROOFS

Roofs may be flat or sloped. In case of sloped roof the slope should be less than 15° to avoid horizontal impact of flying debris.

In case of flat roofs the drainage of the roof should be so designed as to be capable of discharging more than normal rainwater falling in short duration. These rainwater outlets should be properly maintained and kept free from choking.

13 WATER SUPPLY

The following considerations shall be made with respect to water supply to the shelters:

- a) For shelters, a water supply of 75 litre per day per person shall be considered.
- b) Minimum 5 day water storage capacity shall be provided, with 50 percent of water requirement stored on roof top and other 50 percent of water requirement stored on ground.
- c) Minimum of two tanks (Suitably interconnected) should be provided at terrace as well as on ground.
- d) Tank should be manufactured from such material that these do not fly off in high wind. Also these should be suitably anchored.
- e) A battery of six hand-pumps at the first floor level in stilt structures and at the ground floor for non-stilt structures for drawing ground water during normal use as well as emergencies, shall be provided.
- f) Regular cleaning of the terrace at least during the rainy and cyclonic season (April-May and Oct-Dec) such that the harvested water from roof is clean, shall be ensured. The water harvesting system (including the tank) shall be cleaned once in a month in all seasons and water purification system as found necessary, shall be adopted.

14 TOILETS AND SEWERAGE

The following considerations shall be made with respect to sanitation:

- a) There shall be separate male and female toilets. Minimum 1 toilet shall be provided for every 15 males and every 10 females, respectively.
- b) In addition, urinals shall be provided for, at the rate of one every 30 persons.
- c) Size of each toilet should be minimum 1.1 m².
- d) Minimum 4 wash basins be provided for every 100 persons.
- e) Septic tanks provided should be properly sealed and roof sufficiently elevated so as to prevent inundation during flooding.

15 OTHER CONSIDERATIONS

The following additional consideration shall be taken into account:

- a) Elevated approach road may be laid up to the shelter with gravel/concrete.
- b) Provision for appropriate power back-up facilities such as generator/solar power cells may be made. These should be located above the design surge level.

- c) Communication facilities such as wireless radios/walkie-talkies may be provided.
- d) Maintenance and management committees may be formed for the regular maintenance of the shelter, involving the community.
- e) Medical kit consisting of general medicines should be made available for emergencies in the shelters.
- f) Life jackets shall be made available.
- g) Rope/wooden ladder shall be kept inside shelters.
- h) Participatory approach to facilitate maintenance of cyclone shelters should be as per Annex B.

16 PROVISION FOR HELIPADS

Heavy cyclones often inundate large areas and situations may arise that helicopters may have to be used to access the affected areas. The terraces of cyclone shelters may be used to provide space to

land one helicopter, as these are elevated and sturdy structures. The design of the shelter structure should account for the dynamic forces generated during landing/takeoff of the helicopter.

If adequate clear area around the shelter is available to enable the landing of helicopters, this should be utilized instead.

The provision to use helipads should be exercised only when, there are,

- a) large stretches of low-lying areas which are difficult to reach quickly with the available means of water based transport.
- b) areas with higher density of vulnerable populations with high frequency of cyclones.
- c) areas with critical/strategic installations that could prove fatal when a secondary disaster is triggered due to floods and cyclones.

ANNEX A

[Clause 4.4 (p)]

SUSTAINABLE USE OF CYCLONE SHELTERS

A-1 The more a shelter is used in normal time, the better it is maintained and the more successfully it serves in emergencies. The regular use also provides economic justification for the investment. Among a number of alternatives suggested, primary schools have been found to be the most suitable and compatible for normal time use of shelters. These could also be used temporarily for community gatherings, health camps, election booths, etc. The following guidelines would help in sustainable use of the shelters:

- a) The primary use of the cyclone shelter is for protecting people from the vagaries of nature, such as flood, cyclone and tsunami, and to act as relief camp during other disasters.
- b) The shelter should always be made and protected keeping in view all concerns pertinent to its primary use.
- c) The features pertinent to other uses should then be overlapped with those of the primary use of the shelter with no compromise on its primary use.
- d) Broadly, the states will have maximum say on the kind of sustainable use the shelters be put to. States are advised to encourage innovations based on local needs and necessities identified by the village communities should be fitted in.
- e) The use of cyclone shelters for housing the offices which are of a more permanent occupation nature (for example, Panchayat offices and hospitals) has to be discouraged, since these offices cannot be relocated during the periods of occurrence of natural disasters, which occur without prior notice. Hence, these would hinder the usability of the shelter for the primary purpose for which it is meant.
- f) The cyclone shelter should ultimately become a 'Community asset/Resource' such that it will have a broader impact on the livelihood of the villages. Hence, it is appropriate to locate the cyclone shelters inside or near the villages. Ultimately, the idea is to assure their regular use during the normal period as well.
- g) Using the shelter as primary school on regular basis will not come in the way of sheltering since most rural primary schools use mats for seating the children and where low height desks/benches may be used, they could be stored in a small space or used for people sitting or standing on them.
- h) Other temporary uses may be for village gatherings, camps, marriages, and other community activities.
- j) Such a sustainable use should also generate required finances to supplement proper maintenance of the structure.

ANNEX B

[Clause 15 (h)]

PARTICIPATORY APPROACH TO FACILITATE MAINTENANCE OF CYCLONE SHELTERS

B-1 Even strongly built structures can deteriorate in the absence of proper maintenance. Proper maintenance is possible through involvement of communities in planning and design of the shelter, such as a design would include the features necessary for the sustainable use of the shelter. The experience from elsewhere reveals that the communities have actively used these shelters when their opinions were considered in choosing its location and design parameters. Such a participatory approach not only brings the sense of ownership but also the pride of possession. For example, it is logical that a shelter can be used for running a school when

features necessary for a school are also made available in the shelter. However, adequate resources should be made available for maintenance of the shelters.

Cyclone shelters should not be looked upon only as a means of mitigation but also as a means of development as these shelters provide facilities for a wide variety of sustainable uses, such as education and health-care and promote the local development. Efforts should be made to promote local imagination and innovation without leaving any doubts/gaps that would create confusion on important issues.

ANNEX C

(Foreword)

COMMITTEE COMPOSITION

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